Cleaner Production as a Tool to Mitigate Pollution in Leather Processing: Case study

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Abstract – **This study investigates waste management practices and cleaner production (CP) opportunities at the case study tannery. Work seeks to achieve sustainable development through the use of best practices. Ways of achieving compliance with environmental regulations through the application of initiatives, such rationalizing uses of chemicals, water and energy consumption were reviewed as means to reduce waste discharge into the environment and water bodies. Chemical and water consumption levels were presented as pointers to areas where by-products could be considered for recycling and re-use in the plant to improve on productivity. This work sought to reduce salts in the effluents by employing a number of CP measures including installation of a chilling unit to the tannery system.**

Key words - **tannery, waste, discharge, compliance, environment**

I. INTRODUCTION

While the green pressures emphasize on the need to comply with local environmental regulations, the world as a global village is insisting on competitors to adopt responsible production practices [1, 2]. The turbulent economic environment such as the one prevalent in Zimbabwe, where the cost of importing chemicals and energy is increasing in quantum leaps, could be the catalyst required to initiate this transformation. The leather processing is no exception to these pressures as the process is highly intensive on chemical and water consumption, and thereby being inherently wasteful in nature. In the face of “infinite” demand for leather products, it was identified that cleaner production could be a viable business strategy focused on changing attitudes, management styles as well as technologies [3, 8].

II. LEATHER PROCESSING

The process of converting hides and skins into leather is carried out in aqueous medium where extensive use of chemicals to treat and soften hides is employed. Over twenty different chemicals are employed to convert hides and skin into commercial leather [4]. The resulting effluent discharge from tanning drums and paddles contain varied soluble and insoluble contaminants in waste water. Some of the common chemicals that are employed include: lime, sodium sulphide, sodium chloride, enzymes, detergents and wetting agents, hydrochloric and sulphuric acid, chrome sulphate, mimosa extract, sodium bicarbonate, sodium formate, ammonium solution, sodium meta-bisulphite, acid dyes, solvents, formic acids, finishes, aluminium sulphate, oxalic acid and potassium permanganate. From previous studies, only 60% of the chemical is absorbed into the skin, the residue is washed off in preparation for a subsequent process stage. The major processes in leather manufacturing are: curing soaking, liming, de-liming, bating, degreasing, pickling, tannage, dyeing, drying and fining [5].

Curing is carried out to shield freshly flayed skins from attacks by microorganisms, enabling them to be stored for long periods. Most curing operations take place at the abattoir, but mention has been made of this operation because of the huge impact of the material used on both the environment and quality of the final product.

Soaking rehydrates the fibres and tries to bring the skins as close as possible back to the state of green hides. Thus it restores the natural swollen condition of the skin at the same time removing dirt, blood, dung, soluble proteins and curing agents such as salt.

Liming is the treatment of soaking skins with lime to loosen hair on the hide, remove the epidermis and separate fibres as well as fibrils. Liming removes the epidermis together with the hair growing onn it. It prepares the pelt for the tanning process by removing the final cementing substance leaving the final leather pliable and soft. The opening of the fibre structure (depilation) and the degree of swelling plumping control yield area, grain character and the temper of the leather [2]. Hides that have undergone un-hairing are called pelts, and are full of lime. For adequate tanning the lime must be removed and the degree of swelling reduced to levels required for various tannages. Some acid or acid salt is required. This process is called de-liming and is necessary to remove the chemically combined lime. Washing with running water for twenty-four hours is impractical in a factory set up and only removes 60% of the lime.

Bating makes the grain of the leather clean, smooth and fine .The intent is to make the final leather soft pliable and stretchy. Un-bated pelts are of relatives rough and of course leather.

Finishing processes entail final leather treating for the market like conditioning, staking, toggling, trimming, dry milling, buffing, impregnation, leather finishing and plating which results in mainly solid waste summarized by Table I [4].

TABLE I
SOLID WASTE IN TANNERIES [4]

Type of solid waste	**Rate of generation**	**Characteristics of solid waste**	**Comments**
Dusted Salt	0.1 kg/skin	Contains around 120 gm/kg of moisture, 120 gm/kg of volatile matter, 450 gm/kg of salt.	Contaminated with blood, hair, dirt and bacteria. Partly reused in curing and the rest is indiscriminately dumped in undeveloped lands near the tanneries.
Raw Trimmings	0.024 kg/skin	Proteins	The skins are trimmed (especially at legs, belly, neck, and tail parts) in order to give them a smooth shape. The trimmings are usually sold to soap and poultry feed production
Fleshings	0.25kg/skin	Contains around 240 gm/kg of proteins, 200 gm/kg of fats, 3 gm/kg of sulphide.	This is the flesh material of limed skins. It is usually sold to soap and poultry feed makers.
Wet Trimming/ Wet shaving	0.14 kg/skin	Contains around 240 gm/kg of proteins, 30 gm/kg of fats, 15 gm/kg of chromium oxide	After chrome tanning, skins or split hides are shaved to proper thickness. This operation produces solid waste containing chrome. Secondary users including poultry feed makers, usually collect these shaving from the tanners.
Dry Trimmings/ Dry Shaving/Buffing Dust	0.06 kg/skin	Contains around 300 gm/kg of proteins, 130 gm/kg of fats, 30 gm/kg of chromium oxide	Secondary users, including poultry feed makers, collect cuttings and dry trimmings and buffing dust of the leather from the tanneries.
Assorted Refuse	No consistent quantity	Primarily cartons, bags, drums, etc	This is normally sold separately (in bulk) in the retail market.

In the early industrial development the effluents for hide processing could be easily discharged into regular sewers, canal and wastelands without much concern for ecological damage and odor nuisance. But with time, environmentalists have since realized the dangers presented by these chemicals and effluents in contaminating community water sources, damaging soil structure rendering it useless for agriculture, as well as adversely affecting aquatic life. On the other hand, it also dawned on municipal authorities that industry is in fact passing the cost of treating industrial effluent to them, despite their strained financial resources and limited effluent treatment capacity. Even though minimum pollution standards were set, no tannery has managed to consistently comply despite significant investments in waste treatment technology. Against this background, cleaner production becomes the logical route to reduce the pollution load in effluent discharge [6].

Environmental auditing has shown that tannery pollutants are generated in form of solid, liquid and gaseous emissions as given in Table II below [4], with an indication of standard limits.

To address high level polluting challenges the leather processing industry needs to invest in waste minimizing technologies that reduce pollution at source. This could be done by monitoring and reducing water consumption, re-using waste produced in an economically and environmentally viable applications, as well as monitor effectiveness of effluent treatment provisions [7].

TABLE II
POLLUTION LEVELS IN TANNERY EFFLUENTS [4]

Parameters	*Raw sheep & goat skin-finished leather mg/I	**Raw calf hides-finished leather mg/I	***Wet blue (goat& sheep)-finished leather mg/I	Limits Mg/I
PH	9.33-9.88	7.35-7.67	3.52-3.55	**6-10**
BODs (Unfilled) at 60minutes Settling	11050-14827	840-1740	714-1346	**80**
COD(Unfiltered) at 60minutes Settling	41300-43000	1000-2680	2000-3500	**150**
Suspended solid at 0 time settling	4270-4650	820-1920	1970-6620	**150**
Sulphate as SO_4 at 0 time settling	1814-3146	800-860	5480-6480	**600**
Sulphate as (S) at 0 time settling	288-292	1.2-2.6	Nil	**1.0**
Chromium (Cr) at 0 time settling	64-133.3	41	160-194	**1.0**

III. METHODOLODY

An overview of the organization was done by a walk through to identify suffering points of the organization's processes. Collected retrospective data of effluent-quality levels for the organization was used to characterize the discharged wastewater as compliant or non-compliant with municipal and environmental regulations. Material flow charts and process evaluations were used as a basis for generating cleaner production initiatives.

IV. CASE STUDY

Leather Tannery Processors was established in 1987 and it employed 70 workers. The organization specialized in "exotic leathers" which included elephant, hippo, crocodile and ostrich leather. Ostrich leather was the main product, 95 percent of was exported to United States of America, Mexico and the Far East. The inability to meet effluent quality standards stipulated by the municipality and the need to reduce waste in the production set-up, pushed this firm to seek for best practices.

At the tannery, hides were drum-soaked for a period of 24 hours before effecting the first fleshing. The efficiency of the soaking process hinges on the care which has been taken with regard to soak waters that is water softness, bacterial count, water temperature, soak duration, as well as the skin condition, whether they are fresh, wet- salted, dry or dry-salted. The other factor which affects the success of the soaking procedure is the extent of de-naturation in the hides that has been brought by the curing in the various fibrous and globular proteins. A perfectly soaked hide has flexible, slippery handle, almost resembling the green hide. Soaking affects subsequent operations such as un-hairing, opening up and scudloosening which occur at the liming stage. For this reason the operation must be done in a short period that prevents damaging bacterial growth.

This study underscored the need to monitor unit process consumption levels of both chemicals and water. This provided a deep insight into operational processes to rationalize use of chemicals and water. Wasteful areas could be identified so that subsequent modifications could be implemented. Logical alternatives to pressures arising from the regulatory authorities, the economic environment and the market place at large could be generated specifically for the tannery site.

V. RESULTS AND DISCUSSION

A. Effluent quality

Pollution load in treated effluent showed a wide swing in values, this could be attributed to the batch process done different days. These were done to establish compliance with effluent quality standards set by the municipal authorities in mg/l of pollutants. Most organisms can only survive at the neutral pH of fresh water which is 7, while the tests fluctuated from pH of 3 to as high as 12. The municipal limit is set at a range of 6.5 to 12.

B. Chemical oxygen demand (COD)

COD levels were 75% non-conforming, with highest COD level of 15167mg/l, which falls far short of municipal standard set at 2000mg/l. The lowest value achieved was 1721mg/l, and was within limit. The processes that generate COD were the early stages such as soaking, liming, degreasing and dry cleaning that remove fats and grease material.

C. Total suspended solids

For the period under review the total suspended solids started off at 3693mg/l, and this was reduced to 3383 mg/l against a municipal standard of 600mg/l. While solid waste generation is an inherent part of leather processing, level of skill in flaying if poor may result in excess flesh on the skins, so that more solids are generated. Fine screens may further reduce the level of suspended solids to required range.

D.*Sulphates*

Sulphates were generated by three stages namely the de-liming, pickling and tannage stage, these use ammonium sulphate, sulphuric acid and chromium sulphate respectively. Municipal standard level of 500mg/l was achieved easily in the tannery. Also use of carbon dioxide in place of ammonium sulphate in de-liming could go a long way in reducing sulphates.

E.Sulphides

Sulphides are considered to be one of the most dangerous pollutants,and is mostly contributed by the liming operation which uses sodium sulphide. The re-use of lime liquors may results in reduction of chemical discharge of sulphide levels effluent. This would go a long way in protecting workers from sulphide poisoning.

F.Chromium

Chromium discharge was found to be 100% compliant, this was attributed to rigorous process control which optimises chromium uptake in the hides.

G. Chemical use

Common salt or sodium chloride is the most utilized chemical in the chrom tanning process. It accounts for 27% by mass of chemicals used in the plant. This would be more if cure salt is added at abattoir level to preserve the hides. Use of chilling unit can be used to preserve the hides, this way the cost of salts used is substantially reduced.

VI. RECOMMENDATIONS

It was noted that the tannery has been consistently compliant only with respect to chromium discharge. The non-useable material is contaminated with process chemicals a cause for environmental concern.

The current practice of preserving fresh hides by salting them was a major contributor of high toxicity in the tannery effluent. This could be addressed by installing a chilling unit to preserve raw hides to reduce the amount of salts used by the tannery in this process. The resulting salt usage reduction is estimated to be 40 -50% of hide weight. In the beam house there is need to reduce the volume of saline effluents by reusing soaking floats in the counter current method.

Opportunities for further reduction in COD levels may lie the installation of screens, to further cut down on proteinous suspensions in lime and soak liquors.

The effort focused on identifying those areas that consumed the most resources, and had the most emissions or exposed the workforce to hazardous material, with a view to recover, reuse and recycle or substitute.

It is hoped that major polluters such as tanneries develop environmental policies as a background to achieving better environmental performance and increased productivity.

VII. CONCLUSION

It was shown that the firm had a high use-intensity of salt. This could be reduced by direct processing of hides after flaying. Direct processing requires careful planning of process runs. The hides could not be left unprocessed for more than four hours, after which hide would putrefy and be lost completely if chilling system for hides is not put in place. While municipality still carries out snap surveys of discharge into the sewer systems, “the polluter pays” principle is n longer functioning as it should. The cost of polluting is not sufficiently deterrent to force industrialist to seek alternatives within their production systems to meet the requirements of local governments.

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